Virtual Teams for NPD – an Innovative Experience for R&D Engineers

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Abstract:

New interaction tools such as internet allows companies to gain valuable input from research and development (R&D) engineers via virtual teams. Consequently engineers also get more expertise in diminutive timeframes. Virtual R&D teams present the key impetus to the technology acquisition process. The present knowledge-economy era is characterized by short product life-cycles. Virtual R&D teams may reduce time-to-market, make available a large pool of new product know-how and provide greater flexibilities which are the key success factors in a competitive market. This comprehensive review contains almost 100 references and covers the recent literature with emphasis on topic. The review has focused on authentic and reputed publications and extracts the results. This article presents the type of virtual teams and their main features and explains how virtual R&D team can play a prominent role in developing new products. The article is evolved future study guideline and also illustrates how to apply virtual interaction tools and integrate engineers into the innovation process. Management of virtual R&D teams in new product development (NPD) processes in an innovative, effective and efficient is of a high importance, but the issue has been poorly addressed in the previous studies. Findings show that virtual R&D team provides valuable input for new product development and R&D engineers are able to attain virtual experience.

Keywords: Virtual R&D Teams, New Product Development, Virtual Experience, R&D Engineers

Introduction

Information technology is providing the infrastructure necessary to support the development of new organizational forms. Virtual teams represent one such organizational form, one that could revolutionize the workplace and provide organizations with unprecedented levels of flexibility and responsiveness [1]. Virtual teams afford many advantages to organizations, including increased knowledge sharing [2] and employee job satisfaction and commitment, as well as improved organizational performance [3]. Virtual teams are believed to be an important element in future R&D organization [4]. Many research and development (R&D) organizations and teams currently use a specialized knowledge portal for research collaboration and knowledge management [5].

New product development (NPD) teams are integral components of firms that develop, manufacture, and sell technological offerings. Complex NPD tasks are difficult to solve, involving different functional departments, experience of engineers, judgment and tradeoffs [6]. Given the complexities involved in organizing face-to-face interactions between team members and, leveraging the advancements in electronic communication technologies, firms are employing virtual teams in product development activities. Considering the lack of industrial experiences for engineering students, universities look for a suitable situation in which the students can perform a design project not limited to paper calculation. Virtual NPD team can be a solution to compensate the lack of industrial experience of engineer students.

This paper with a comprehensive review of literature and related resources covering the topic presents type of virtual teams, examples of uses of virtual team, and their benefits, draw back and main features and explains how virtual R&D team can play a prominent role in developing new products. The article also illustrates NPD and its relationship with virtuality and elaborates different NPD process and finally team effective virtual team will also be discussed.

Definition of Virtual Team

Gassmann and Von Zedtwitz [4] defined "virtual team as a group of people and sub-teams who interact through interdependent tasks guided by common purpose and work across links strengthened by information, communication, and transport technologies". Another definition suggests that virtual teams, are distributed work teams whose members are geographically dispersed and coordinate their work predominantly with electronic information and communication technologies (e-mail, video-conferencing, telephone, etc.) [7], different authors have identified diverse. Along with Bal and Teo [8] it could be concluded that a team will become virtual if it meets four main common criteria and other characteristics that are summarized in

Table 1. Geographically dispersed teams allow organizations to hire and retain the best people regardless of location. The temporary aspect of the team appears less emphasized [9] although [8, 10, 11] included temporary in virtual team definition but some authors like Gassmann and Von Zedtwitz [4] use may be temporary for some team members.

Table 1 Common criteria of virtual team

Characteristics of virtual team	**Descriptions**	**References**
Common criteria	1. Geographically dispersed (over different time zones)	[9, 11-15]
	2. Driven by common purpose(guided by a common purpose)	[4, 7, 8, 13, 16]
	3. Enabled by communication technologies	[8, 9, 14, 15]
	4. Involved in cross-boundary collaboration	[4, 8, 16, 17]
Other characteristics	1. It is not a permanent team	[8, 10, 11, 18, 19]
	2. Small team size	[8]
	3. Team member are knowledge workers	[8, 20]
	4. Team members may belong to different companies	[12, 19]

A summary of definition of virtual team may be taken as: small temporary groups of geographically, organizationally and/or time dispersed knowledge workers who coordinate their work predominantly with electronic information and communication technologies in order to accomplish one or more organization tasks

Types of Virtual Team

Generally, we can differentiate various forms of "virtual" work depending on the number of persons involved and the degree of interaction between them. The first is "*telework*" (telecommuting) which is done partially or completely outside of the main company workplace with the aid of information and telecommunication services."*Virtual groups*" are composed of two or more teleworkers engaged in a lasting relationship, pursuing a common interest and each member reports to the same manager [21]. In contrast, a "*virtual team*" exists when the members of a virtual group interact with each other in order to accomplish common goals. Finally, "*virtual communities*" are larger entities of distributed work in which members participate via the Internet, guided by common purposes, roles and norms. In contrast to virtual teams, virtual communities are not implemented within an organizational structure but are usually initiated by some of their members [22]. Examples of virtual communities are open source software projects [7]. Teleworking is viewed as an alternative way to organize work that involves the complete or partial use of ICT to enable workers to get access to their labor activities from different and remote locations [23]. Telework provides cost savings to employees by eliminating time-consuming commutes to central offices and offers employees more flexibility to co-ordinate their work and family responsibilities [24].

Examples of Uses of Virtual Team

Working in today's business world is like working in a world where the sun never sets. Rezgui [16] investigates the effectiveness of virtual teams, and any other suitable form of virtual collaboration, in the construction sector, and explores the factors that influence their successful adoption. May and Carter [25] in their case study of virtual team

working in the European automotive industry have shown that enhanced communication and collaboration between geographically distributed engineers at automotive manufacturer and supplier sites make them get benefits are better quality, reduced costs and a reduction in the time-to-market (between 20% to 50%)for a new product vehicle. New product development (NPD) requires the collaboration of new product team members both within and outside the firm [23, 26, 27] and NPD teams are necessary in almost all businesses[19]. In addition, the pressure of globalization competition companies face increased pressures to build critical mass, reach new markets, and plug skill gaps , NPD efforts are increasingly being pursued across multiple nations through all forms of organizational arrangements[28]. Given the resulting differences in time zones and physical distances in such efforts, virtual NPD projects are receiving increasing attention [26]. The use of virtual teams for new product development is rapidly growing and organizations can be dependent on it to sustain competitive advantage[29].

Benefits and Draw Back of Virtual Team

The availability of a flexible and configurable base infrastructure is one of the main advantages of agile virtual teams. Virtual R&D teams which members do not work at the same time or place [30] often face tight schedules and a need to start quickly and perform instantly [31]. As a drawback, virtual teams are particularly vulnerable to mistrust, communication break downs, conflicts, and power struggles [32]. On the other hand, virtual teams reduce time-to-market [25]. Lead time or time to market has been generally admitted to be one of the most important keys for success in manufacturing companies [33]. Table 2 summarizes some of the main advantages and Table 3 some of the main disadvantages associated with virtual team. We are in a transient phase that is pushing out beyond the envelope of team fundamentals into a space where we begin to lose track of reality [34]. Clearly the rise of network technologies has made the use of virtual teams feasible [35]. Finally organizational and cultural barriers are another serious impediment to the effectiveness of virtual teams. Many managers are uncomfortable with the concept of a virtual team because successful management of virtual teams may require new methods of supervision [36].

Table 2: some of the main advantages associated with virtual team

Advantages	**Reference**
Reducing relocation time and costs, reduced travel costs (Virtual teams overcome the limitations of time, space, and organizational affiliation that traditional teams face [37])	[26, 38-48]
Reducing time-to-market [Time also has an almost 1:1 correlation with cost, so cost will likewise be reduced if the time-to market is quicker [49]]	[25, 33, 42, 43, 48, 50-57]
Able to tap selectively into center of excellence, using the best talent regardless of location	[3, 40, 41, 43, 45, 58-61]
Greater degree of freedom to individuals involved with the development project	[43, 60, 62]
Greater productivity, shorter development times	[26, 54]
Producing better outcomes and attract better employees, Generate the greatest competitive advantage from limited resources.	[38, 63, 64]
Optimize the contributions of individual members toward the completion of business tasks and organizational goal	[59]
Better team outcomes (quality, productivity, and satisfaction)	[37, 65, 66]
Higher team effectiveness and efficiency	[25, 67]

Table 3: some of the main disadvantages associated with virtual team

Disadvantages	**References**
Decrease monitoring and control of activities	[68]
Vulnerable to mistrust, communication break downs, conflicts, and power struggles	[29, 32, 40, 69, 70]
Challenges of determining the appropriate task technology fit	[34, 60, 71-74]
Cultural and functional diversity in virtual teams lead to differences in the members' thought processes. Develop trust among the members are challenging	[31, 42, 60, 61, 72, 73, 75-78]
Sometimes requires complex technological applications	[39, 60]

New Product Development

Product development definition used by different researchers with slightly different ways but generally it is the process that covers product design, production system design and product introduction processes and start of production [79]. New product development (NPD) is widely recognized as a key to corporate prosperity [80]. The

product life cycle of goods grows shorter every year. Today, leading-edge firms can exploit global asset configurations to customize existing products and services, and they also have the ability to combine their resources with an expanding knowledge base to create a continuous stream of new products and services [81]. With the needs to respond quickly to dynamic customer needs, increased complexity of product design and rapidly changing technologies, the selection of the right set of NPD is critical to a company's long-term success [82] . Also combination of factors such as ever changing market needs and expectations, rough competition and emerging technologies among others, challenges industrial companies to continuously increase the rate of new products to the market to fulfill all these requirements [33].The ultimate objective of all NPD teams is superior marketplace success of the new product [83]. In light of the above product innovations are central in securing a firm's competitive advantage in international markets [84]. NPD is vital and needs to be developed both innovatively and steadily [82].

NPD and virtuality

New product development (NPD) has long been recognized as one of the corporate core functions [85]. During the past 25 years NPD has increasingly been recognize as a critical factor in ensuring the continued existence of firms [86].The rate of market and technological changes has accelerated in the past years and this turbulent environment requires new methods and techniques to bring successful new products to the marketplace [87]. Particularly for companies with short product life cycles, it is important to quickly and safely develop new products and new product platforms that fulfill reasonable demands on quality, performance, and cost [88]. The world market requires short product development times [89] therefore in order to successfully and efficiently get all the experience needed in developing new products and services, more and more organizations are forced to move from traditional face-to-face teams to virtual teams or adopt a combination between the two types of teams[17]. Given the complexities involved in organizing face-to-face interactions among team members and the advancements in electronic communication technologies, firms are turning toward employing virtual NPD teams [60, 76, 90]. New product development requires the collaboration of new product team members both within and outside the firm [23, 26, 27] and NPD teams are necessary in almost all businesses[19]. In addition, the pressure of globalization competition companies face increased pressures to build critical mass, reach new markets, and plug skill gaps , NPD efforts are increasingly being pursued across multiple nations through all forms of organizational arrangements[28]. Given the resulting differences in time zones and physical distances in such efforts, virtual NPD projects are receiving increasing attention [26]. The use of virtual teams for new product development is rapidly growing and organizations can be dependent on it to sustain competitive advantage[29].

New product development process

Today's uncertain and dynamic environment presents a fundamental challenge to the new product development process of the future [91]. New product development is a multi-dimensional process and involves multiple activities [27]. Several authors proposed different conceptual models for the NPD process, beginning from the idea screen and ending with the commercial launch. Kusar al. [52] summarized different stage of new product development which in earlier stages , the objective is to make a preliminary market, business, and technical assessment whereas at the later stages the propose is to actually Design and develop.

1- Definition of goals (goals of the product development process)
2- Feasibility study (term plan, financial plan, pre-calculation, goals of market)
3- Development (first draft and structure of the product, first draft of components, product planning and its control processes)
4- Design (design of components, drawing of parts, bills of material)

The model of Cooper Figure 1, called the Stage-Gate System is one of the most widely acknowledged system in NPD [92]. The Stage-Gate System model divides the NPD into discrete stages, typically five stages. Each stage gathers a set of activities to be done by a multifunctional project team. To enter into each stage, some conditions and criteria have to be fulfilled. They are specified in the Gates. A Gate is a project review in which all the information is confronted by the whole team. Some criticism of the method has surfaced, claiming that the steering group assessment in the gate step halts the project for an unnecessarily long time, making the process abrupt and discontinuous [88]. A closer integration of management through virtual team in the process might be a solution for avoiding such situations.

Stage-Gate process is a method of managing the new product development process to increase the probability of launching new products quickly and successfully. The process provides a blueprint to move projects through the different stages of development: idea generation, preliminary investigation, business case preparation, product development, product testing, and product introduction. This process is used by such companies as IBM, Procter & Gamble, 3M, General Motors, and others. The process is primarily used in the development of specific commercial products, and is more likely to be used in platform projects than in derivative projects.

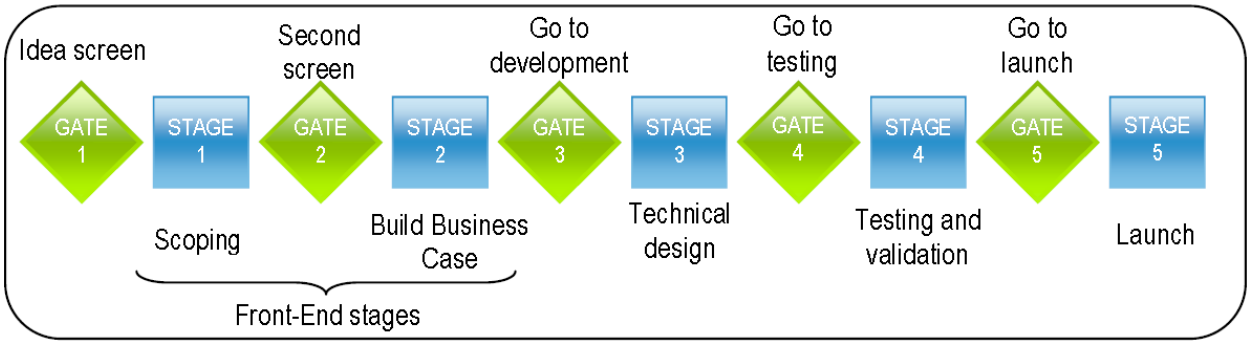

Figure 1 The Stage-Gate system model (source Cooper [93])

Development Stage-Gate System in NPD process: The new products plan will support the strategic objectives of the firm and make the best use of its strategic competencies. As it is illustrated in Figure 2, the development stages of the NPD process include the generation of new product ideas, the development of an initial product concept, an assessment of its business attractiveness, the actual development of the product, testing it within the market, and the actual launch of the product in the marketplace. Alongside each of these stages, an evaluation takes place, essentially to determine whether the new product should advance further or be terminated [94].

Effective Virtual Team

A review of the literature shows the factors that impact on the effectiveness of virtual teams are still ambiguous. Many of the acknowledged challenges of effective virtual team working, focus on ensuring good communication among all members of the distributed team [95]. For example, Jarvenpaa and Leidner [36] found that regular and timely communication feedback was key to building trust and commitment in distributed teams. Lin et al.[96] study indicates that social dimensional factors need to be considered early on in the virtual team creation process and are critical to the effectiveness of the team. Communication is a tool that directly influences the social dimensions of the team and in addition the performance of the team has a positive impact on satisfaction with the virtual team.

For teams moving from co-location to virtual environments, an ability to adapt and change can be a long process riddled with trial and error scenarios. This process is seen as necessary to encourage effective virtual teams[69]. Despite weak ties between virtual team members, ensuring lateral communication maybe adequate for effective virtual team performance. In terms of implementation, lateral communication in both virtual context and composition teams can be increased by reducing the hierarchical structure of the team (i.e. a flatter reporting structure and/or decentralization) and the use of enabling computer-mediated communication tools[11].

Malhotra and Majchrzak's [97]study of 54 effective virtual teams found that creating a state of shared understanding about goals and objectives, task requirements and interdependencies, roles and responsibilities, and member expertise had a positive effect on output quality. As criteria, effectiveness ratings were Hertel et al.[7] collected from the team managers both at the individual and at the team level. The results of the field study showed good reliability of the task work-related attributes, teamwork-related attributes, and attributes related to tele-cooperative work.

Shachaf and Hara [67]suggests four dimensions of effective virtual team leadership:

1. Communication (the leader provides continuous feedback, engages in regular and prompt communication, and clarifies tasks);
2. Understanding (the leader is sensitive to schedules of members, appreciates their opinions and suggestions, cares about member's problems, gets to know them, and expresses a personal interest in them);

3. Role clarity (the leader clearly defines responsibilities of all members, exercises authority, and mentors virtual team members); and
4. Leadership attitude (the leader is assertive yet not too "bossy," caring, relates to members at their own levels, and maintains a consistent attitude over the life of the project).

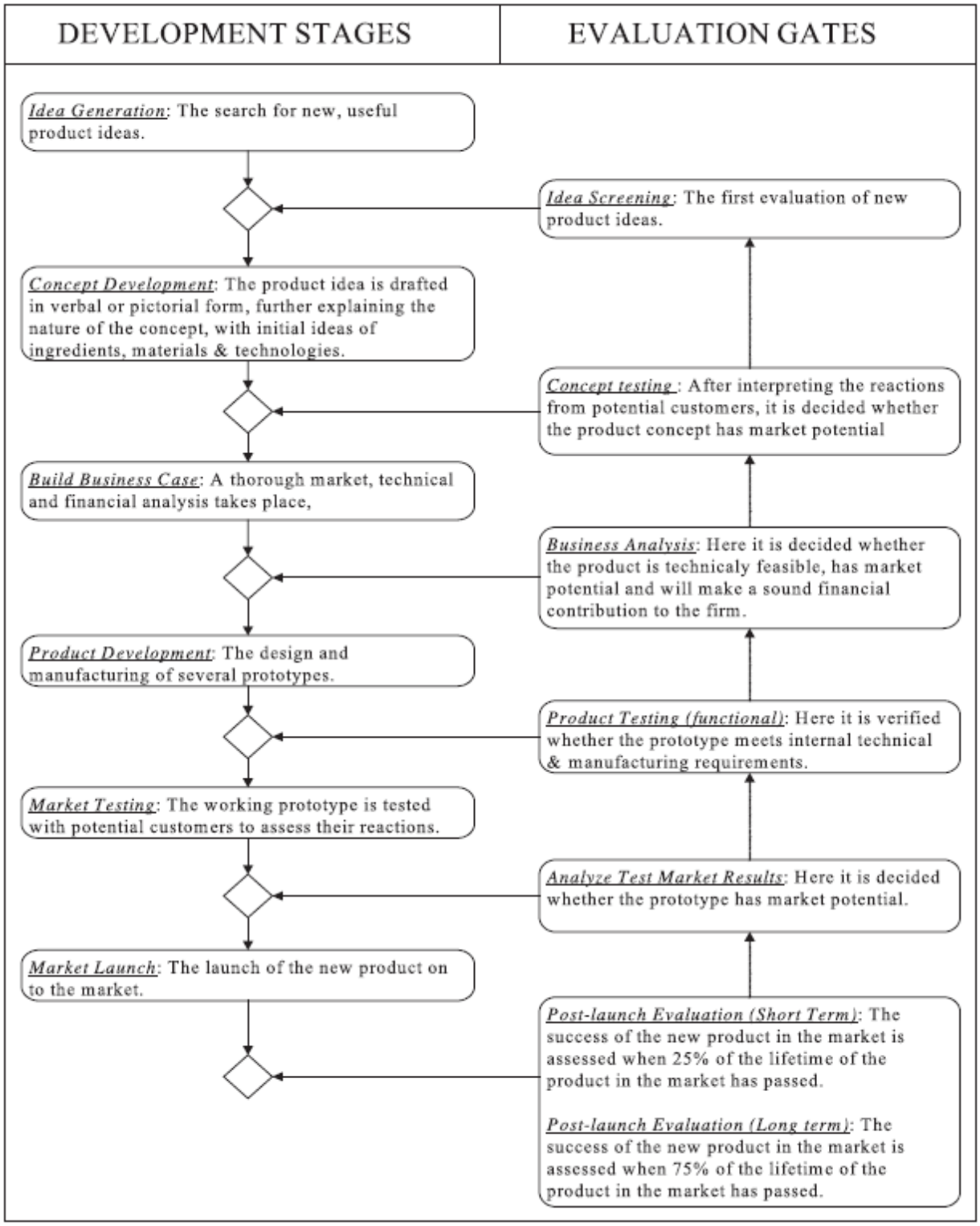

Figure 2 Development stages and evaluation gates in the NPD process (Source: [94]).

Conclusion

Competitive business environments and social pressures are driving the adoption of virtual team working. This paper with a comprehensive review of literature and related resources covering the topic, find that success in implementing virtual team working is more about processes and people than about technology. Organizations are often naive about the advantages, problems and disadvantages of virtual team working. Virtual teams offer many benefits to organizations striving to handle a more demanding work environment, but also present many challenges and potential pitfalls. With comparing Table 2, with Table 3 it is clearly obvious that advantages of utilize virtual teams are far from its disadvantages so dealing with it can bring new findings. Virtual teams are a new and exciting work form with many fascinating opportunities. Due to these opportunities, virtual teamwork becomes increasingly popular in organizations and institutions. A suitable situation in which the students can perform a design project not only limited to paper calculation but also earn industrial experiences is working as a virtual NPD team member.

Future research would now seem to be essential for developing a comprehensive study, combining literature survey with case study in different size of companies (e.g. multinational companies and small and medium enterprises) and various type of activities (e.g. research and development and new product development). Such a study would provide an assessing what patterns, practices, or types of activities must virtual NPD teams carry out to achieve effectiveness in the competitive environment?, How such teams should be managed? What types of process structure and technology support should be provided for facilitating such teams?, What different methods of virtual team are uses today and how effective are they?, What benefits and problems arise as a consequence of the creation of virtual team? What is role of different collaborative technologies in supporting the virtual team? and How to make the transition from a more traditional team structure to the more distributed team structure?. These questions and many other practical questions wait for future empirical investigation.

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